Physiological and Cognitive Correlates of Child Abuse

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ABSTRACT

Objective: To compare the physiological responses of abused children to different stimuli with responses of children in a reference group and to correlate the physiological responses with intellectual and personality functioning. **Method:** Abused children were compared with a reference group on two batteries of tests that were administered on separate days. In one session, children were shown slides with emotional or cognitive content while heart rate, pulse height, skin conductance, electromyography, and skin temperature were measured. In the other session, intellectual and personality functioning was measured using the WISC-R, Quick Neurological Screening Test, and the Junior Eysenck personality inventory. **Results:** Abused children had smaller changes in pulse height in the first two stimulus conditions presented ("No Signal" and "Math"), but their electrodermal responses were lower throughout all stimulus conditions. Abused children also had higher introversion and lower Verbal and Full Scale IQ scores. Verbal and Full Scale IQ scores were inversely related to the severity of abuse that had been experienced. When these variables were used in a discriminant function analysis, children were assigned to the correct group 86% of the time. **Conclusion:** These findings support a model that describes the effects of abuse as delaying cognitive development and inhibiting physiological responsiveness to the environment. *J. Am. Acad. Child Adolesc. Psychiatry,* 1995, 34, 8:1067–1075. **Key Words:** child abuse, physiology, cognition.

It is well documented that abuse is associated with altered cognitive development in children. Bowlby (1976) demonstrated that these children had significant intellectual and emotional delays, and Cohn (1979) showed that abused children had language and psychomotor deficiencies. Furthermore, Green observed that physically abused and neglected children had neuropsychological deficits when compared with a control group (Green, 1983; Green et al., 1981). In a longitudinal study, Cicchetti and Rizley (1981) found abused children to have psychomotor deficits and to be socially maladjusted. Salzinger et al. (1984) assessed 64 maltreated children (physical, sexual, emotional abuse and neglect) and 48 nonmaltreated children from an outpatient clinic. Scores on the WISC-R and Wide Range Achievement Test indicated that maltreated children had lower academic achievement and IQ scores than a control group. Wildin et al. (1991) found that 39% of abused preschooler children had developmental delays and 46% of abused school-age children had academic difficulties.

The mechanisms underlying poor cognitive functioning in abused children are not well understood. The pioneering studies of Kempe et al. (1962) and Caffey (1972) lead to the hypothesis that mental retardation observed in physically abused children is a direct consequence of brain trauma from blows to the head and/or vigorous shaking. However, Martin et al. (1974) showed that many children who had suffered brain lesions as a result of physical abuse showed no learning or neurological impairment, whereas other abused children with no demonstrable nervous system pathology showed learning difficulties. Green et al. (1981) compared a group of physically abused children to a group of neglected children and a normal control group. To

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their surprise, they found similar levels of impairment in children from the abused and the neglected groups. This called into question the view that cognitive impairment was a direct result of the abuse, and investigators began to search for other factors in the abusive environment (e.g., poverty, poor or chaotic parenting, understimulation and unstable learning environment) that might be responsible for the cognitive impairments.

Later studies attempted to control for the confounding effect of lower socioeconomic status on the cognitive development of the abused child. Oates and Peacock (1984) found that physically abused children scored lower on the WISC-R and the Wechsler Preschool and Primary Scale of Intelligence when compared with nonabused peers matched for sex, ethnic group, and socioeconomic status of parents. Einbender and Friedrich (1989) showed that sexually abused girls had lower cognitive abilities and school achievement compared with a control group matched for age, race, family income, and family constellation. Although these studies provided clear evidence for the deleterious effects of abuse per se on the cognitive development of children, other nonspecific environmental factors probably exacerbated the vulnerability of abused children in an interactive or additive manner.

Few studies to date have focused on the underlying psychophysiology that might play a mediating role in the cognitive difficulties of children who have suffered abuse. Numerous investigators have demonstrated the key role of the visceroautonomic component (heart rate and skin conductance changes) in preparing the organism to respond to or ignore environmental stimuli (Graham and Clifton, 1966; Lacey et al., 1962; Sokolov, 1960). Sokolov showed that novel stimuli elicited "orienting reflexes" that were associated with momentary cardiac deceleration and which, presumably, were physiological correlates of the attentional process(es).

Lacey et al. (1962) studied physiological responses of college students in a series of stimulus conditions that required internal or external focusing. They found that cardiac deceleration was associated with "taking in" or focusing on information coming from the environment, whereas cardiac acceleration was associated with tasks requiring internal focusing (e.g., a math task) or "blocking out" the environment. Whatever the direction of change in the physiological response (cardiac acceleration or deceleration), Lacey et al. demonstrated the importance of the autonomic nervous system response in producing either facilitative or blocking effects on information processing.

Recent psychophysiological and neurohormonal data obtained in children have indicated that trauma and abuse can affect a variety of biophysiological systems and that some of these effects persist long after the trauma. Ornitz and Pynoos (1989) demonstrated that children with posttraumatic stress disorder experienced a significant loss of the normal inhibitory modulation of the startle response 17 to 21 months after the traumatic experience. Hill (1989) reported that a group of hospitalized abused and nonabused children had lower heart rates than nonhospitalized controls in response to videotaped situations of everyday conflict, a result that appeared counterintuitive to the expectation that abused children would show hyperarousal to such a situation. Rogeness et al. (1989) detected a trend for higher dopamine β-hydroxylase levels in abused and neglected boys, which may indicate excess noradrenergic activity. Jensen et al. (1991) measured abnormal patterns of growth hormone responses to clonidine and L-dopa challenges with differential effects for sexually and physically abused boys. De Bellis et al. (1994a) found that sexually abused girls had blunted adrenocorticotrophic hormone responses to corticotropin-releasing factor challenge compared with controls. This may reflect hypothalamic-pituitary-adrenal axis dysfunction as a result of adaptation to chronic trauma or stress. In addition, this group found that this population of sexually abused girls had higher urinary excretion of homovanillic acid, presumably indicating increased noradrenergic activity (De Bellis et al., 1994b). Hypothetically, disturbances in physiological or neurohormonal functioning in abused children are reflective of the more serious impact of chronic trauma on CNS functioning as opposed to the more transient effects of less serious trauma.

Differential physiological reactivity is necessary for successful adaptation to the environment. This type of response seems to be lost in traumatized people who experience states of hyperarousal in response to stimuli suggestive of the previous trauma (see Kolb, 1987; van der Kolk, 1987). Yehuda et al. (1991, 1993) demonstrated hormonal dysregulation in Vietnam combat veterans which appeared to be due to the reduced effects of cortisol in producing negative feedback in the hypothalamic-pituitary-adrenal axis. If the traumatic experience is overwhelming and/or unremitting, the

hyperarousal becomes chronic and can generalize to other non–trauma-related stimuli in the environment. With respect to children, the effects of trauma through abuse could have a serious impact on their physiological functioning and subsequent cognitive development.

The purpose of the present study was twofold: (1) to determine whether the physiological responses of abused children to different stimulus conditions could differentiate them from the responses of children with no known abuse history; and (2) to correlate the physiological responses with cognitive and personality functioning.

METHOD

Subjects

The experimental group consisted of 18 children (13 girls and 5 boys) between 7 and 13 years of age. Abused children were solicited by the researchers through contacts with social workers from the Children's Aid Society of Ottawa-Carleton, the Protection de la Jeunesse of the Outaouais region, and the Children's Outpatient and Day Treatment Center of the Centre Hospitalier Pierre Janet. Abuse was defined as physical or sexual assaults serious enough to warrant official legal investigation and confirmed by medical or psychiatric examinations.

A reference group was chosen that was matched to the experimental group for age, sex, and level of parental income and education. The reference group was solicited from the same geographic area. When school principals were contacted, the nature of the study was explained and they were asked to supply students who were average in intelligence. Students were selected who could be matched for sex, age, and parental socioeconomic level to the experimental group. The school principals then asked the parents of the selected children to attend a meeting at which the rationale of the study was explained by the research assistant. All parents who attended the meeting subsequently agreed to allow their children to participate and signed informed-consent forms. The guardians of the abused children—either the biological parents or the foster parents—were contacted individually and had the nature of the research study explained to them, after which they signed the informed-consent form.

For both groups, exclusion criteria included mental retardation, poor physical health, any neurological disorder, evidence of serious accidents during childhood, and a history of multiple foster home placements (more than two). No screening was done to detect abuse in the reference group, but one parent spontaneously volunteered that one of her children had been physically abused and this child was then switched to the experimental group.

Relevant data describing the two groups include that 63% of abused children had repeated one or more grades, compared with 6.6% of the children in the reference group, and 73.6% had been or were in a foster home, compared with 0% for the reference group. At the time of testing, 63.0% of the abused children were in foster care.

To characterize further the experimental group, the following abuse characteristics were recorded:

1. Type of abuse: sexual abuse only, 53% (10 girls); physical abuse only, 15% (2 boys and 1 girl); combined sexual and physical abuse, 32% (4 boys and 2 girls).
2. Age of onset of abuse before or after age 7 years: 58% were before 7 years.
3. Duration of abuse less than or more than 1 year: duration was more than 1 year for 79% of children.
4. Frequency of abuse less than or more than five episodes: 84% of children experienced more than five abusive episodes.
5. Intensity of abuse: for sexual abuse, greater intensity was defined as penetration as opposed to fondling; and for physical abuse, greater intensity was defined as the presence of scars, burns, or marks as opposed to beatings that left no marks; 72.2% of the children had experienced abuse of greater intensity.

The abusers were all known to the children, with 50% being the natural father, 27.7% the stepfather, and 5.5% for each of brother, cousin, uncle, and neighbor. Of the experimental group, 26% had been hospitalized on a children's psychiatric ward but none were hospitalized at the time of testing. The abused children who were in a foster home had been placed there at least 3 months previously. The time between the end of the abuse and the time of testing varied from 3 months to 36 months. Most of the children showed ongoing signs of posttraumatic stress disorder (intrusive recollections, constricted affect, sleep disturbances, etc.), and attention deficit disorder had been diagnosed in one child and conduct disorder in five children.

Procedure

After a familiarization session with the laboratory, each child underwent a cognitive and a physiological assessment which were completed during separate visits. Cognitive testing consisted of the WISC-R and the Quick Neurological Screening Test (QNST). The Junior Eysenck personality inventory was also administered during the cognitive testing in order to measure personality functioning. Physiological testing consisted of the administration of different stimulus conditions which were designed to test the child's ability to concentrate and to respond to emotional and cognitive stimuli. Heart rate, electrodermal activity, temperature, neuromuscular tension, and digital pulse volume (pulse height) were continuously recorded during the presentation of eight stimulus conditions.

Physiological measurements were made using a Davicon Medac System/3 automated system while the child was seated in a comfortable chair beside the experimenter. Bilateral skin conductance electrodes (Beckman silver-silver chloride electrodes) were secured with Velcro straps to the medial phalanges of the first and second fingers using 0.5% KCl in 2% agar-agar as the electrolyte. The EDA (electrodermal activity) unit of the Davicon featured simultaneous tonic and phasic responses. Digital pulse volume, temperature, and heart rate were monitored with a photoplethysmography device attached to the medial phalanx of the nondominant hand. The device contained both the photoelectric sensor and the thermometer used for monitoring skin temperature. The photoplethysmography monitored five distinct measurements of cardiovascular response: heart rate, interbeat interval, rise/fall time, and blood pulse volume. In addition, the Davicon Medac system provided electromyographic (EMG) recordings from two placements (the forearm of the nondominant hand and the forehead). Electrodes were attached with a Davicon Triple Stix, a three-piece dry disposable attachment (Davicon P/N AE-178), using snap heads (Davicon P/N AE-128). The units of measurement were microvolts.

Eight stimulus conditions were presented on slides projected in front of the child while the seven physiological measures were recorded. The stimulus conditions were designed to elicit different physiological reactions and were presented in the same order for each child. The total time for the physiological testing was 27 minutes, with each condition taking between 3 and 4 minutes. The eight stimulus conditions were (1) relaxation (Relax1); (2) a no-signal condition in which the child is shown some slides but is not asked to respond (No Signal); (3) math calculations (Math); (4) Children's Apperception Test-Part 1 (CAT1); (5) Children's Apperception Test-Part 2 (CAT2); (6) Halstead Category Test-Part 1 (HCT1); (7) Halstead Category Test-Part 2 (HCT2); and (8) final relaxation (Relax2). (The CAT1 and CAT2 show animals in domestic conflict; the HCT1 and HCT2 measure a child's ability to form concepts.)

Statistical Analyses

All analyses were performed using SPSS/PC or BMDP/PC90 software on a microcomputer running under DOS. A two-way (abused versus reference group; males versus females) multivariate analysis of variance (MANOVA) was carried out for the Verbal, Performance, and total scores from the WISC-R, the QNST, and the two Junior Eysenck scales (Anxiety and Introversion-Extroversion). A similar MANOVA was performed on the baseline values (responses in condition 1) for all seven of the physiological measures. In addition, for the physiological variables, a three-way MANOVA with one within-subjects (eight stimulus conditions) and two between-subjects variables (group and gender) was carried out for all seven physiological variables. Analyses were performed using absolute measures, change scores for each condition versus baseline (condition 1), and percentage of baseline for each condition (e.g., condition 2 divided by condition 1 and multiplied by 100). Since results were similar regardless of the method used, only the percentage of baseline analyses is reported here. These analyses control for individual variability because each child served as his or her own control.

Because the primary purpose of this experiment was to determine the variables that discriminated abused children from children in a reference group, several discriminant function analyses (DFAs) were performed using the jackknifed classification procedure. The first DFA determined whether the absolute physiological responses at baseline (condition 1) combined with the percentage change from baseline for the other seven conditions (conditions 2 to 8) could differentiate children from the abused and reference groups. The second DFA determined whether Verbal, Performance, or Full Scale IQs on the WISC-R in conjunction with the Junior Eysenck scales and the QNST could differentiate children from the abused and reference groups. Finally, those variables found to be discriminators in either the first or second DFA were entered into a third DFA to determine the final classification results. For each analysis, the jackknifed procedure was used to reduce bias in estimating the classification rates. In this procedure, data for each case are left out when the coefficients used to assign that case to a group are computed (Tabachnick and Fidell, 1989).

Stepdown analyses (described by Tabachnick and Fidell, 1989) were carried out to determine the extent to which the predictors identified by the DFAs were accounting for unique variance in the model. This procedure involves a series of ANOVAs with covariates (ANCOVAs), with the highest priority variable analyzed first and lower priority variables analyzed with the contribution of all higher priority variables removed by treating them as covariates.

No specific adjustments were made for multiple comparisons, although only the most important "a priori" comparisons that were related to the stated hypotheses concerning differences in psychophysiological responding between the two groups were identified. On the other hand, the main purpose for assessing the cognitive and personality status of the children was to provide a description of the abused and comparison groups so that they can be compared to subjects used in other studies in the literature. In this respect, analyses of the cognitive and personality characteristics of the abused and comparison groups were not directly related to the main hypotheses and were considered independent "a priori" analyses. As well, the number of "data-dependent" comparisons were kept to a minimum following the guidelines suggested by Smith et al. (1987).

Therefore, the main hypotheses were related to the question of whether the abused group (given that they had characteristic deficits in cognitive and personality functioning as reported in the literature; e.g., lower Verbal IQ) could be differentiated from the comparison group based on psychophysiological responses to various stimuli. Further analyses were performed to determine whether the psychophysiological and cognitive and personality variables were accounting for the same or different (i.e., unique) variance in discriminating between cases in these two groups.

The second objective was to determine whether there were any relationships among descriptive variables for the experimental group and physiological and intellectual functioning. The main purpose of these analyses was to describe the characteristics (e.g., type and severity) of abuse experienced by the children and to determine whether these variables were related to the measured physiological and/or cognitive and personality variables of the abused children. These descriptive variables were gender, severity of abuse, type of abuse, relationship to abuser, whether the child repeated a grade, placement in a foster home, previous psychiatric hospitalization, and time between the end of abuse and testing. Severity of abuse was a compound index composed of intensity, frequency, and duration of abuse. These analyses were exploratory in nature and involved ANOVAs, t tests, and Pearson correlation coefficients. The results from these exploratory analyses were used to describe further the relationship(s) between the abuse characteristics and physiological, cognitive, and personality variables in the group of abused children. Because of the small number of subjects in the abused group, the results from these exploratory analyses were interpreted with caution.

RESULTS

The means (±SD), F ratios, and probability values for the Verbal, Performance, and Full Scale IQ scores on the WISC-R; Introversion-Extroversion and Neuroticism scores from the Junior Eysenck; and QNST scores are shown in Table 1. The baseline values (i.e., responses in condition 1) for the seven physiological measures are shown in Table 2. The abused children were significantly more introverted and displayed lower Verbal and Full Scale IQs than did the reference group. Overall, there was a positive correlation between scores on the Introversion-Extroversion scale and both Verbal (r = .48, p = .003) and Full Scale IQ (r = .43,

TABLE 1
Intellectual and Personality Functioning of Reference and Abused Groups

Variable	Mean ± SD	Statistic
E scale		
R	17.4 ± 2.4	$F(1,32) = 6.59$, $p = .015$
A	16.0 ± 2.0	
N scale		
R	12.1 ± 4.8	$F(1,32) = 3.55$, $p = .069$
A	15.8 ± 5.9	
L scale		
R	5.0 ± 2.4	$F(1,32) = 0.44$, $p = .514$
A	4.9 ± 2.3	
Verbal IQ		
R	96.4 ± 8.1	$F(1,32) = 35.6$, $p < .001$
A	81.0 ± 7.8	
Performance IQ		
R	107.2 ± 9.5	$F(1,32) = 3.22$, $p = .082$
A	99.3 ± 13.3	
Full Scale IQ		
R	101.3 ± 8.3	$F(1,32) = 18.4$, $p < .001$
A	88.4 ± 8.8	
QNST		
R	14.1 ± 7.2	$F(1,32) = 3.16$, $p = .085$
A	19.3 ± 9.2	

Note: Means (±SD) and multivariate analysis of variance results for the WISC-R Verbal, Performance, and Full Scale IQ scores; the Introversion-Extroversion and Neuroticism scores from the Junior Eysenck; and the Quick Neurological Screening Test (QNST) scores are shown for the reference (R) and abused (A) groups. There were 13 girls and 5 boys in each group.

$p = .008$). Furthermore, there was a strong negative correlation between the severity of abuse experienced and Verbal ($r = -.61$, $p < .001$) and Full Scale IQ ($r = -.49$, $p = .002$). As well, there was a tendency for the abused children to have higher Neuroticism scores and to score higher on the QNST. The only difference between the abused and reference groups on the physiological responses during the baseline condition was in the EMG response from the nondominant forearm. Abused children showed an EMG response threefold higher than that of normal children.

The MANOVAs for the seven physiological measures (percentage of baseline) in each of the stimulus conditions yielded several significant effects. There was a significant difference between the abused and reference groups in the galvanic skin response (GSR) across all stimulus conditions ($F[1,32] = 6.21$, $p = .018$). The GSR for the abused children was significantly lower than that for the reference group (Fig. 1).

The group by trial interaction was statistically significant for the pulse height dependent variable ($F[7,26] = 5.44$, $p = .001$). The pulse height for the abused group was significantly lower than for the reference group during the first two conditions (No Signal and Math) after the baseline condition (Fig. 2). These differences may have been due to the slower habituation (response) rate of the abused children relative to the reference group rather than differences in response to the specific stimulus conditions.

The first DFA was performed using the absolute measures for the physiological variables during the baseline condition (Relax1) and the percentage of baseline response for the physiological responses to the seven stimulus conditions (No Signal, Math, CAT1, CAT2, HCT1, HCT2, Relax2). Pulse height in the No Signal and Relax2 conditions, and QRS fall time in the CAT1 condition, were the best discriminators. Using these three variables, 91.7% of the children were correctly classified; 83.3% of the abused group and 100% of the reference group were correctly classified.

The second DFA was performed using the personality, WISC-R, and QNST variables. This analysis indicated that Verbal IQ score was the only significant

TABLE 2
Baseline Physiological Measures for Reference and Abused Groups

Variable	Mean ± SD	Statistic
Heart Rate (BPM)		
R	82.8 ± 8.9	$F(1,32) = 1.24$, $p = .275$
A	88.7 ± 12.7	
Pulse height		
R	7.0 ± 2.3	$F(1,32) = 0.02$, $p = .895$
A	7.0 ± 2.9	
QRS fall time		
R	0.58 ± 0.06	$F(1,32) = 1.98$, $p = .169$
A	0.54 ± 0.07	
Temperature		
R	90.1 ± 2.0	$F(1,32) = 0.15$, $p = .701$
A	89.8 ± 3.3	
GSR		
R	5.1 ± 3.6	$F(1,32) = 0.31$, $p = .585$
A	5.4 ± 2.6	
EMG (forearm)		
R	1.1 ± 0.5	$F(1,32) = 4.99$, $p = .033$
A	3.3 ± 3.9	
EMG (forehead)		
R	4.5 ± 8.1	$F(1,32) = 0.70$, $p = .410$
A	6.5 ± 6.9	

Note: Mean (±SD) and multivariate analysis of variance results for the baseline physiological measures (condition 1) are shown for the reference (R) and abused (A) groups. There were 13 girls and 5 boys in each group. BPM = beats per minute; GSR = galvanic skin response; EMG = electromyogram.

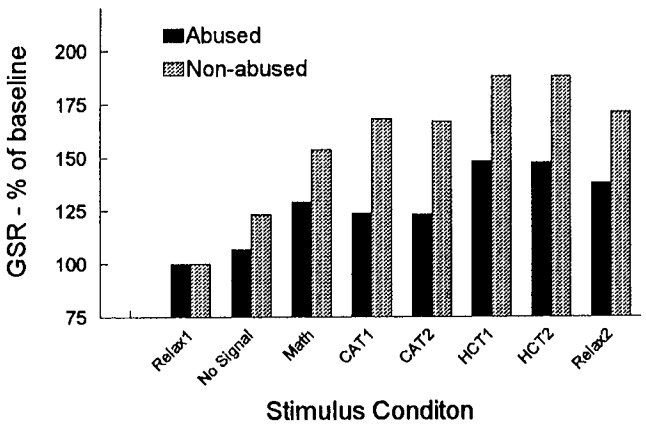

Fig. 1 Mean percentage of baseline galvanic skin response (GSR) in each stimulus condition for the reference and abused groups. The eight stimulus conditions were relaxation (Relax1); a no-signal condition (No Signal); math calculations (Math); Children's Apperception Test-Parts 1 and 2 (CAT1 and CAT2); Halstead Category Test-Parts 1 and 2 (HCT1 and HCT2); and final relaxation (Relax2). Main effect of abuse: $F(1,32) = 6.21$, $p = .018$.

discriminator between the abused and reference groups. Using only this variable, 80.6% of the children were correctly classified, with 83.3% of the abused and 77.8% of the children in the reference group classified correctly.

Using the discriminating variables from the first and second DFAs, Verbal IQ score and pulse height in the No Signal condition were found to provide the best overall results, that is, the best classification rate with the smallest number of variables. Using only these two variables, 86.1% of children were correctly classified; 88.9% of the abused group and 83.3% of the reference group were classified correctly.

Stepdown analyses verified the results from the DFA. Verbal IQ was a significant predictor variable ($F[1,34] = 34.07$, $p < .001$) and, with the contribution of Verbal IQ controlled for in an ANCOVA, pulse height in the No Signal condition was also found to be a significant predictor variable ($F[1,33] = 12.26$, $p = .001$).

Additional exploratory analyses with t tests or ANOVAs were performed to determine whether characteristics of the abused group were related to physiological or intellectual functioning. Children who had been less frequently abused had a greater mean percent change in pulse height for the Halstead Category Test (HCT1, $F[1,17] = 9.17$, $p = .008$; and HCT2, $F[1,17] = 7.90$, $p = .012$). The heart rate response in the HCT1 condition was significantly different according to the type of abuse ($F[1,16] = 8.18$, $p = .004$). Children reporting only sexual abuse had the smallest change in heart rate, the combined group was next, and the physically abused group had the largest change in heart rate. Children placed in a foster home (before or during testing) had smaller percent changes from baseline for the EMG response from the nondominant arm in conditions 3 to 8. Since these children had also experienced more severe abuse ($t[7] = 2.79$, $p = .013$), the data were reanalyzed using severity as a covariate and only conditions 7 (HCT2) and 8 (Relax2) remained significant ($F[1,16] = 5.53$, $p = .032$ and $F[1,16] = 11.1$, $p = .004$, respectively). These data were interpreted as meaning that the children with a history of foster care usually had experienced the most severe abuse. The hospitalized children showed a trend toward lower mean Verbal IQ compared with those not hospitalized (74.8 ± 8.3 versus 82.8 ± 6.9; $t[16] = 1.98$, $p = .066$, two-tailed). Children who had repeated a grade had significantly lower Verbal ($t[16] = 2.24$, $p = .039$) and total IQ ($t[16] = 2.23$, $p = .04$) than children who had not repeated a grade.

Finally, other exploratory analyses indicated that there was a significant positive correlation between the severity variable and the time between the end of abuse and testing ($r = .47$, $p = .048$). As well, there was a significant negative correlation between the Extroversion scale and the time between the end of abuse and testing ($r = -.50$, $p = .034$).

DISCUSSION

The primary purpose of this study was to determine whether psychophysiological and cognitive measures could differentiate abused children from a reference group. Using the unbiased jackknifed classification procedure, the results of the first DFA determined that the combination of two physiological measures in three stimulus conditions (pulse height in the No Signal and Relax2 conditions, and QRS fall time in the CAT2 condition) correctly classified 91.7% of the children. In the DFA using cognitive variables, only Verbal IQ was a significant discriminating variable, correctly classifying 80.6% of the children. When these variables were entered into a stepdown analysis, pulse height in the No Signal condition and Verbal IQ were the two major significant predictor variables.

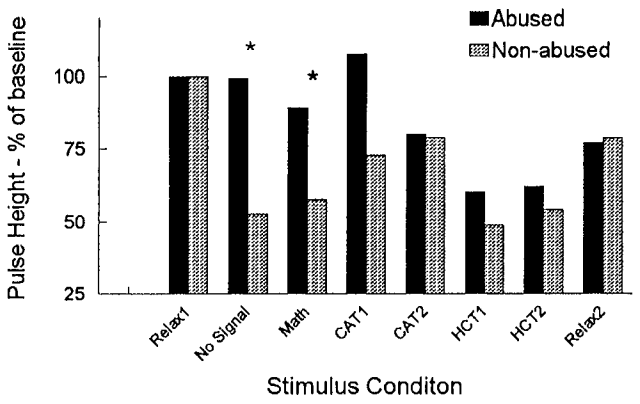

Fig. 2 Mean percentage of baseline pulse height in each stimulus condition for the reference and abused groups. The eight stimulus conditions were relaxation (Relax1); a no-signal condition (No Signal); math calculations (Math); Children's Apperception Test-Parts 1 and 2 (CAT1 and CAT2); Halstead Category Test-Parts 1 and 2 (HCT1 and HCT2); and final relaxation (Relax2). Abuse × condition interaction: $F(6,26) = 4.03$, $p = .006$. $^*p < .01$.

The smaller changes from baseline in the abused children for pulse height in the No Signal and Math conditions and for the GSR measure in all seven conditions are suggestive of inhibited physiological responsivity. Pulse height is an index of peripheral vasoconstriction and vasodilation, with smaller pulse height values (indicating vasoconstriction) generally interpreted as arousal and a readiness to respond to stimuli. Cardiovascular and electrodermal responses, as well as other measures of autonomic responding, have been found to be impaired in various populations of psychiatrically ill children (James and Barry, 1984).

The reduced responsivity may be due to the abused children's reaction to an ambiguous or potentially threatening situation. Alternatively, the abused child may be slow to react in a novel situation. It may be argued that the abused group reacted poorly to the No Signal and Math conditions because of an order effect, that is, a carryover effect from the first stimulus condition (Relax1). This, in itself, is important because the reference group did not show this response.

Hill et al. (1989) observed, contrary to their expectation of increased heart rate, that hospitalized (abused and nonabused) children had decreased heart rates while watching videotaped scenes of ordinary and conflictual domestic childhood scenes. This result went against the commonly held assumption that distress should be accompanied by an increase in heart rate or similar physiological parameters of hyperarousal (Sroufe and Waters, 1977). The critical parameters may be whether the abused child is given the opportunity to respond or not, the time to response, and/or the ambiguity of a novel situation. Presumably, the more ambiguous a situation, the more hypervigilant an abused child would be expected to be. Physiological responses to the hypervigilance may be either blunted or overcompensated, depending on situational, personality, and/or abuse characteristics.

Another important finding was that abused children had reliably lower Verbal IQ scores, which has been reported by other authors (Friedrich et al., 1983; Salzinger et al., 1984; Tarter et al., 1984). In fact, we found that Verbal IQ scores were negatively correlated with the severity of abuse that had been experienced. Although this correlational result was from a series of exploratory analyses and could have occurred by chance, we believe that it is important to report this finding in support of the relationship between abuse and Verbal IQ. It is hoped that by reporting this relationship we will stimulate other investigators to attempt to assess abuse characteristics more quantitatively in the future. If more sensitive measures of severity (or intensity) of experienced childhood abuse are developed, studies investigating the relationship of childhood abuse to subsequent intellectual functioning would be facilitated.

Language skills in general are thought to be very susceptible to disruption in abused children (Law and Conway, 1992; Cicchetti and Beegly, 1987). Lewis (1992) speculated that maltreated children have poorer expressive language skills because abused toddlers are less able than nonabused children to express their feelings in words. It may be that abusive environments affect a child's verbal abilities by raising their anxiety level, which, in turn, disrupts attention, short-term memory, and language-mediated concept formation (e.g., abstract reasoning skills such as ability to identify analogies and similarities). The neurological mechanisms mediating verbal processes are known to develop rapidly before puberty; therefore, if the child is abused during this time period, there may be profound and permanent effects on verbal processes (Lenneberg, 1967). This is consistent with recent views of how traumatic events affect limbic structures mediating arousal levels (Teicher et al., 1993), which may be

partially responsible for the disruptive effects of traumatic events on information processing (N.J. Carrey, unpublished; Hartman and Burgess, 1993)

It could be argued that the physiological differences between the two groups were a consequence of higher estimated Verbal and Full Scale intelligence in the reference group rather than a consequence of abuse. Inasmuch as the tasks presented in the different conditions during physiological measurements were quite simple and did not require analytical skills, it is unlikely that the abused group was required to exert more intellectual effort. Furthermore, the physiological responses that differentiated the abused and reference groups were still significant when estimated intellectual functioning was factored out.

In a series of elegant experiments, Dodge et al. (1990) showed how abused children's physiological and cognitive responses can be affected by their perceptions (i.e., processing) of stimuli. This is consistent with our data, which indicated that physiological and cognitive responses could be affected by the abused child's perception of stimuli. In our group of abused children, it appeared that the abuse had long-term cognitive and physiological effects. Taken together, these findings support the hypothesis that early abusive environments lead to an overall inhibition in both physiological and verbally mediated cognitive responding to the environment.

The results indicate the usefulness of measuring both physiological and cognitive variables in abused children. Further studies are required to determine whether physiological measures can be helpful in distinguishing short- versus long-term effects of abuse and in separating the effects of abuse (as a physiological dysfunction) from the more nonspecific environmental deprivation that may affect both neglected and abused children. A child who shows consistent physiological dysfunction may benefit from a combination of relaxation and/or cognitive therapy and the restructuring of his or her learning environment.

This research was limited by the heterogeneity of the abuse groups and the abuse variables, the absence of longitudinal monitoring, and difficulties in determining short- versus long-term consequences of abuse. There is a need to develop more objective and sensitive assessment techniques to measure the type and severity (or intensity) of abuse suffered by children. Future studies should also carefully control experimental situations in which patient characteristics (abuse versus neglect) are tested against different stimulus conditions (nature of stimulus, timing, ability to respond) to yield a more characteristic psychophysiological profile of the child's functioning and degree of disturbance. Optimally, this should be done with a consideration of the ecological context of the child's environment (e.g., family and school), where the cognitive domain has been shown to be correlated with affective dimensions (Cicchetti, 1984). Educators and parents may then learn to adapt and pace the demands of the learning situation more appropriately for these disturbed children.

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